INTRODUCTION TO SPADES

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Pacific Forestry Service, Canadian Forest Service

SpaDES virtual workshop

June 11-13th, 2024

OUTLINE

1. What is SpaDES?
2. Why SpaDES
    1. New expectations for (ecological) modellers
    2. R^{3}T and PERFICT workflows
3. SpaDES basics

BRIEF INTRO TO SPADES

SpaDES is:

- **Spa**tial **D**iscrete **E**vent **System**
- Meta-package in R
- A toolkit/platform
- Modelling standard
- Whatever you can code in R

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SpaDES is <u>not</u>:

- A (landscape/ecological) model
- The R-equivalent of LANDIS-II
- Necessarily spatially or temporally explicit

BRIEF INTRO TO SPADES

MODULARITY

METADATA

NIMBLENESS

BRIEF INTRO TO SPADES

MODULARITY

METADATA

NIMBLENESS

WHY DO WE NEED/WANT THIS?

NEW EXPECTATIONS

Nimbleness

we must be ready to repeat and adapt analyses/models to new data, new questions/issues and new scientific knowledge

Broad participation

we must include knowledge and participation from both scientific and non-scientific communities

Scrutiny

we must accept and embrace scientific and non-scientific scrutiny

NEW EXPECTATIONS

1. **repeatability**
2. **reproducibility**
3. **reusability**
4. **transparency**
5. **forecasting**
6. **validation**
7. **open-data/open-models**
8. **testing**

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R³T WORKFLOWS

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Repeatability ≠ Reproducibility ≠ Reusability

agreement of results obtained by the same individual using same methods

agreement of results obtained by two individuals/groups using same methods

ability to re-use the same methods in a different context (e.g. new study area)

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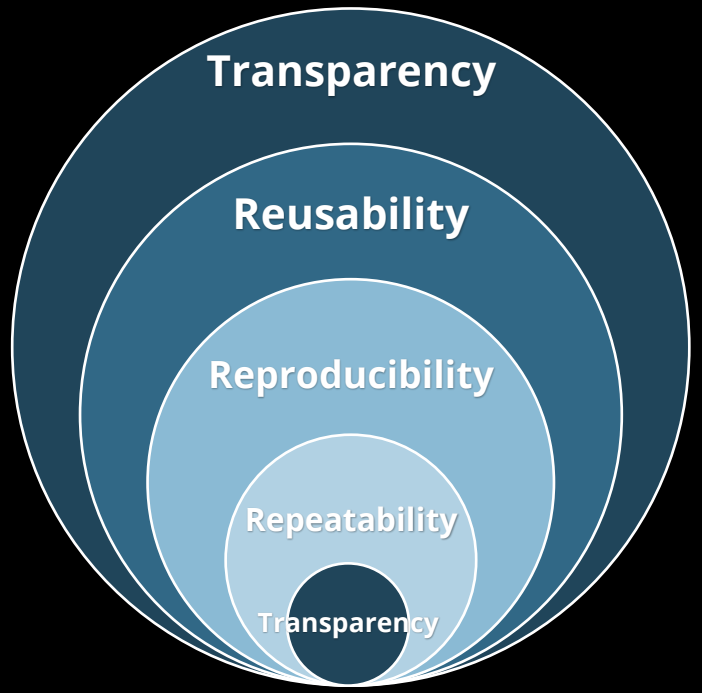
R³T WORKFLOWS



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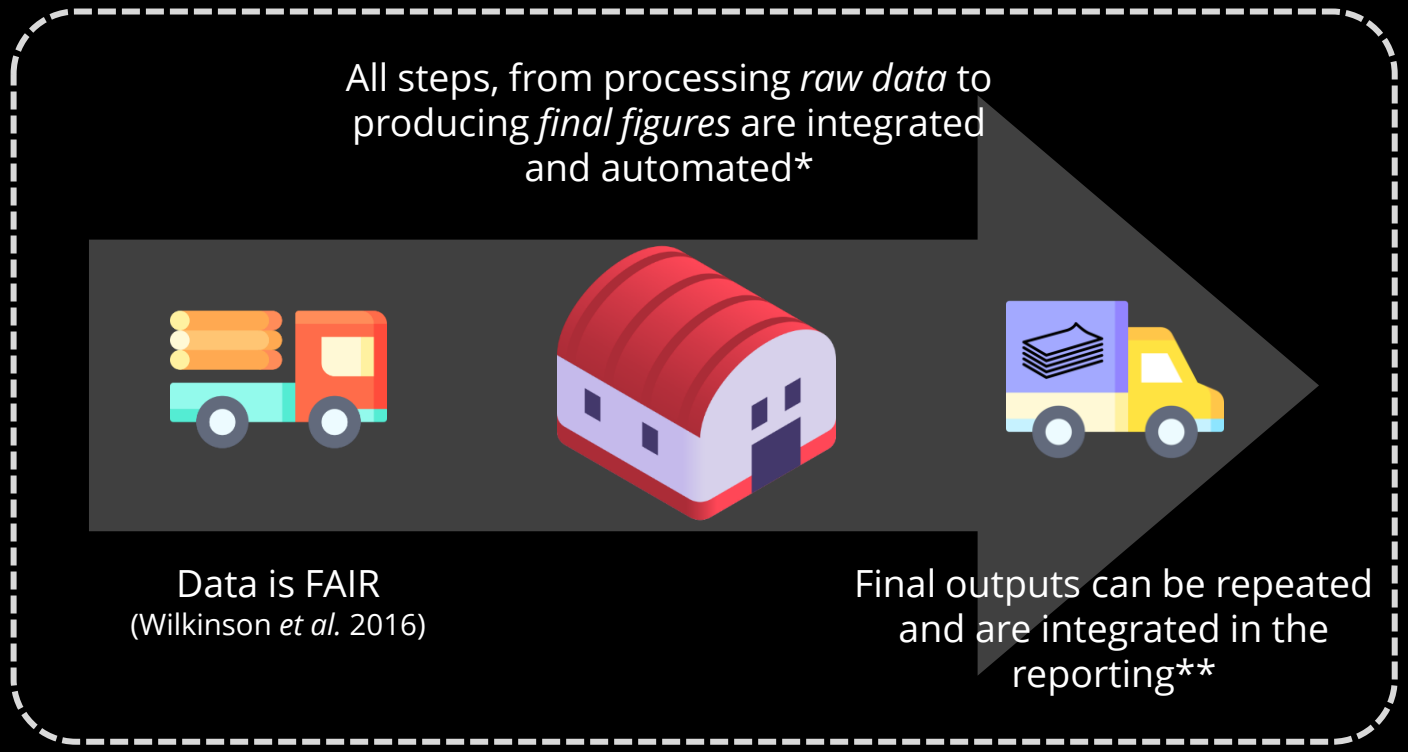

*as much as possible
**directly, or indirectly via links

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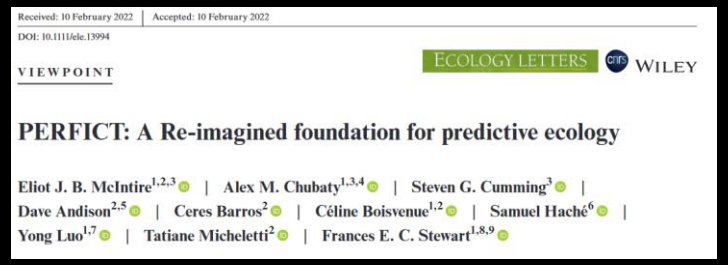
PERFICT WORKFLOWS

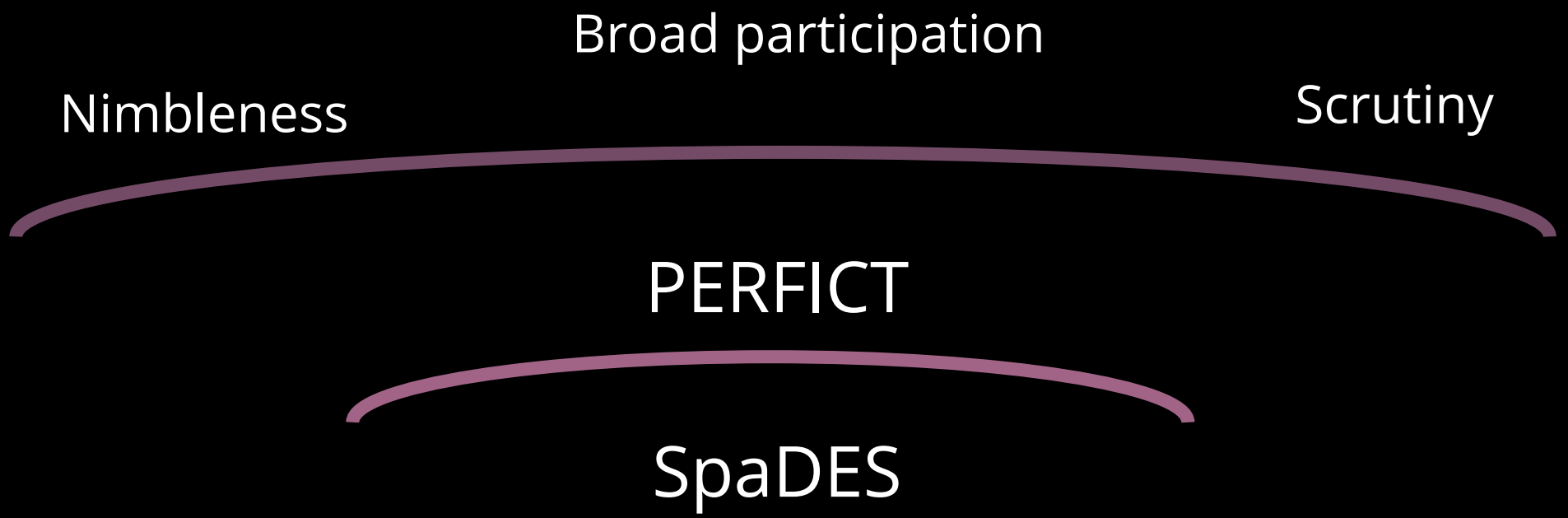

Received: 10 February 2022 | Accepted: 10 February 2022
DOI: 10.1111/ele.13994
VIEWPOINT
ECOLOGY LETTERS WILEY

PERFICT: A Re-imagined foundation for predictive ecology

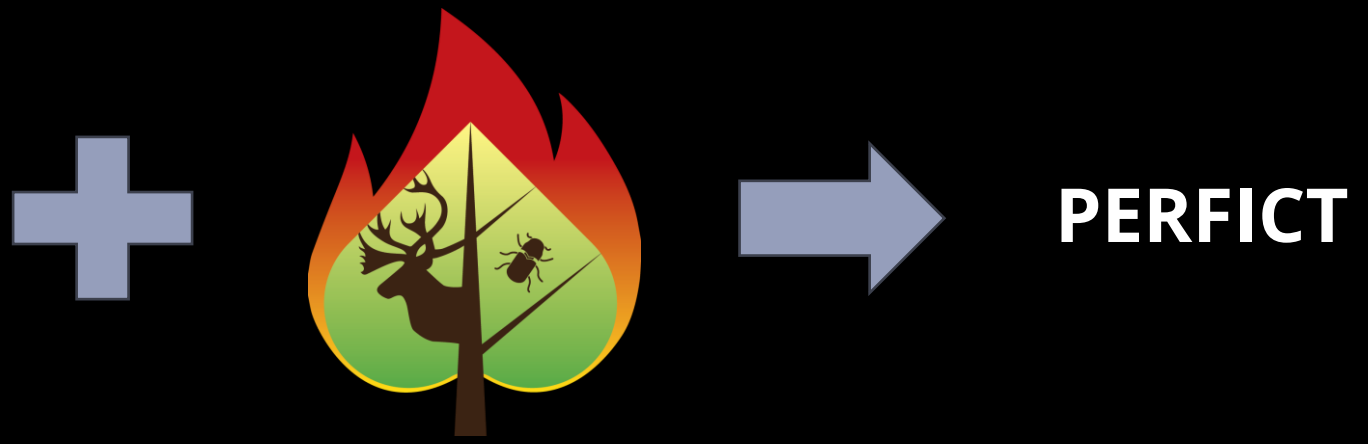
Eliot J. B. McIntire[1,2,3] | Alex M. Chubaty[1,3,4] | Steven G. Cumming[3] |
Dave Andison[2,5] | Ceres Barros[2] | Céline Boisvenue[1,2] | Samuel Haché[6] |
Yong Luo[1,7] | Tatiane Micheletti[2] | Frances E. C. Stewart[1,8,9]

*make frequent **P**redictions and **E**valuations of **R**eusable, **F**reely accessible, **I**nteroperable models, built within **C**ontinuous workflows that are routinely **T**ested*

USING SPADES TO MEET EXPECTATIONS



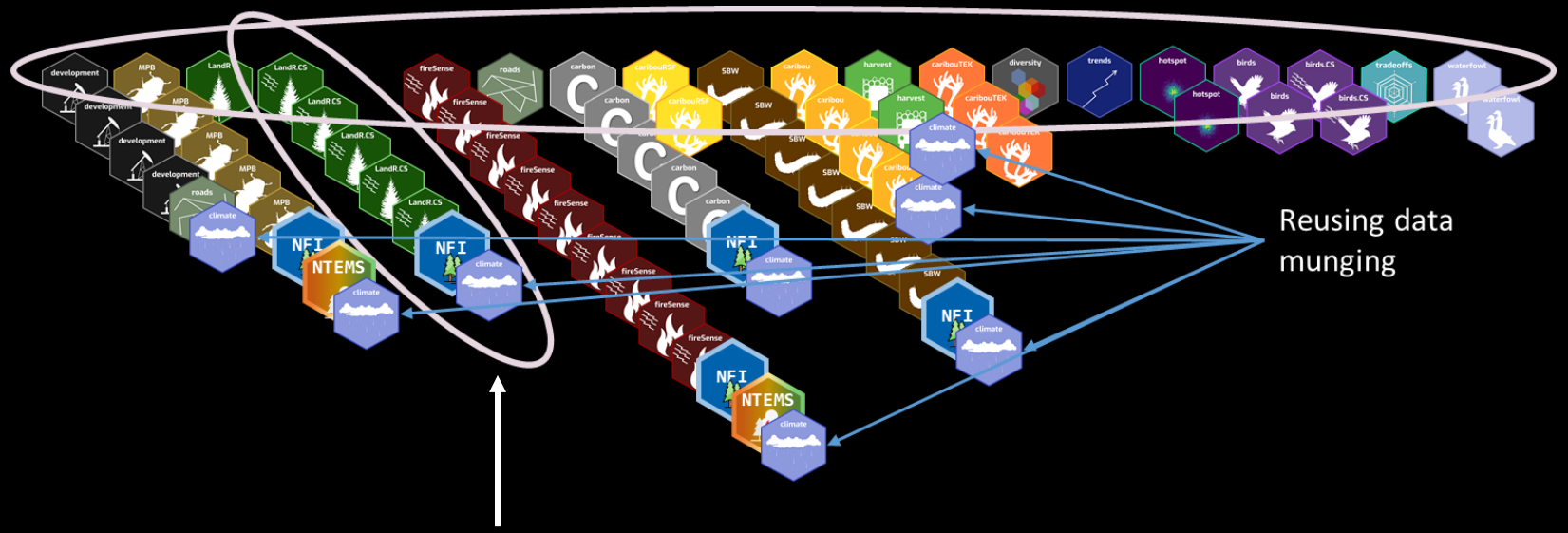
SPADES 101



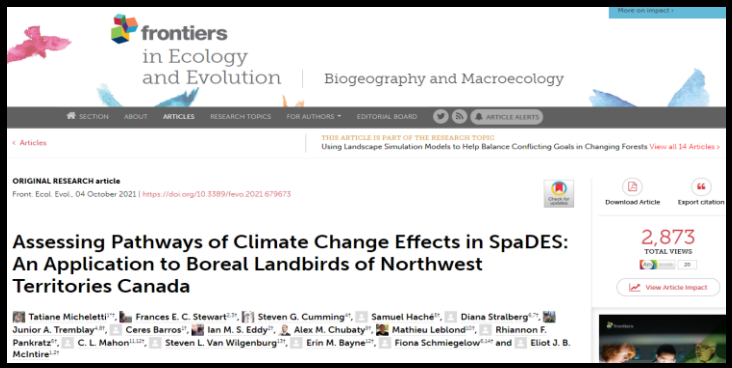
PERFICT

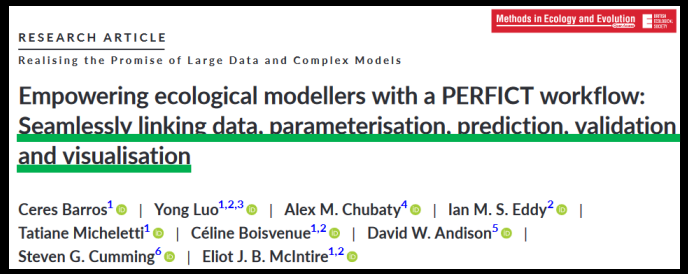
Me before SpaDES

USING SPADES TO MEET EXPECTATIONS



Reusing data munging





Vertical integration with several collaborators/developers

Horizontal integration with collaborators across many disciplines and several stakeholders

SUMMARY

- We are being challenged – accept the challenge!
- R^3T and PERFICT are principles that (should) permeate our work more and more
- SpaDES is a tool that facilitates the meeting the challenges and expectations we now face
- SpaDES is not a model
- Combining **SpaDES + git + single piece of software** (e.g., R), will take you even further!

USEFUL RESOURCES

Peer-reviewed:

- Barros, C., *et al.* (2023). *Methods Ecol Evol*, 14, 173–188.
- Braga, P.H.P., *et al.* (2023). *Methods in Ecol and Evol*, 14, 1364–1380.
- Brousil, M.R., *et al.* (2023). *Methods in Ecol and Evol*, 14, 1381–1388.
- Ellison, A.M. (2010). *Ecology*, 91, 2536–2539.
- McIntire, E.J.B., *et al*. (2022) *Ecology Letters*. 00:1-7
- Micheletti *et al.* (2021). *Frontiers in Ecology and Evolution*, 9.
- Thomas, R.Q., *et al.* (2023). *Frontiers in Ecology and the Environment*, 21, 112–113.
- Wilkinson, M.D., (2016). *Sci Data*, 3, 160018.

Reproducible workflows:

Ecological Forecasting Initiative. (2020). *Reproducible Forecasting Workflows*. *Ecological Forecasting Initiative*. Available at: https://ecoforecast.org/reproducible-forecasting-workflows/. Last accessed 6 July 2023.

The Practice of Reproducible Research

http://www.practicereproducibleresearch.org/

GitHub Quickstart

https://docs.github.com/en/get-started/quickstart/hello-world

Software:

RStudio
R
GitKraken
Git

SPADES BASICS

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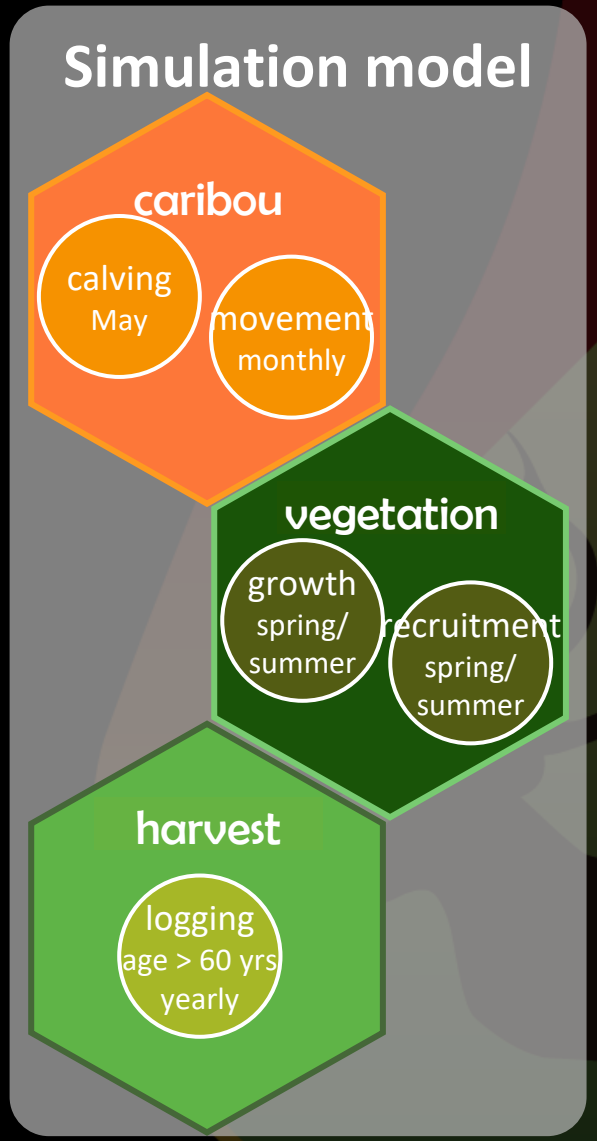
- ✓ Models are composed of interacting *modules*
- ✓ Modules have a known structure and metadata
- ✓ Modules are composed of *events*



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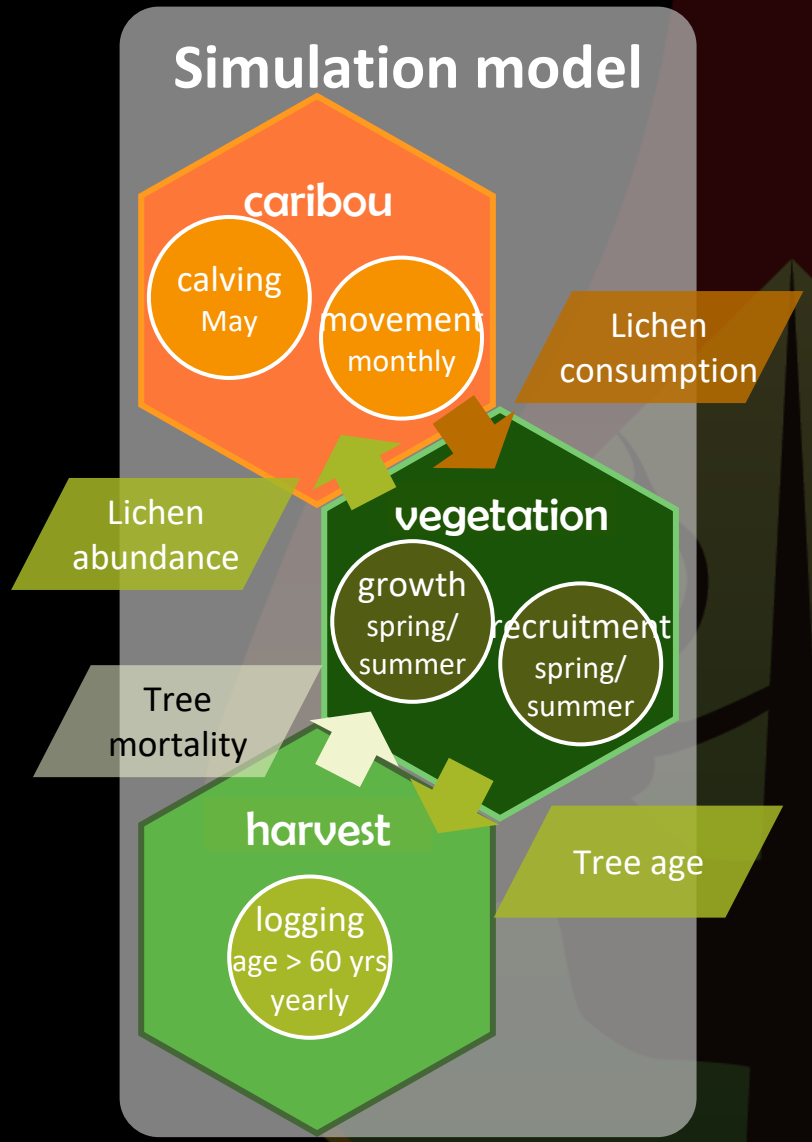

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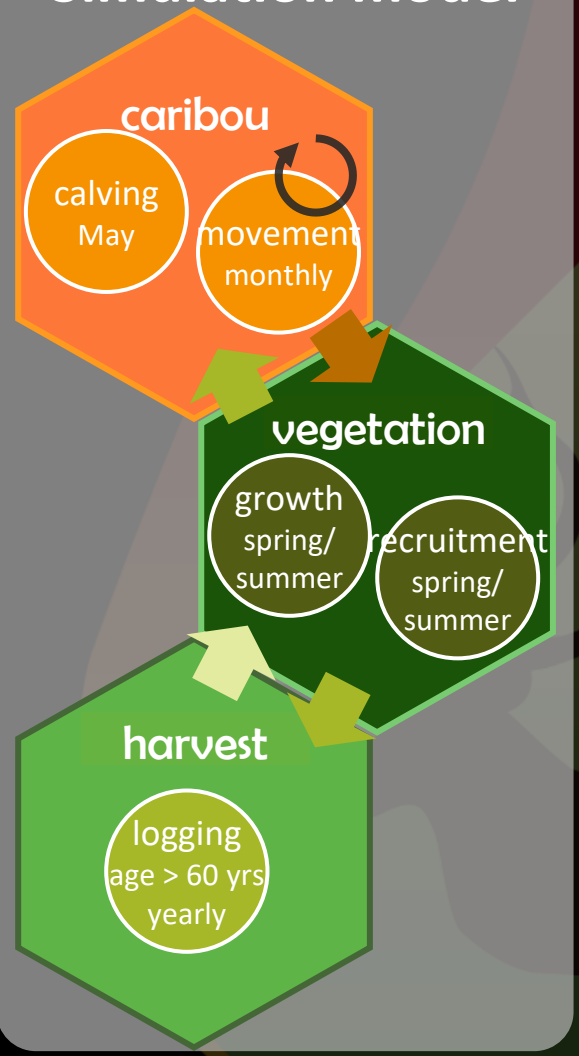
- ✓ Time units can be as small as seconds – automatic cross-scale scheduling

Simulation model



Event sequence

	Month	Year
movement	Jan	1
movement	Feb	1
movement	Mar	1
movement	Apr	1
growth	Apr	1
movement	May	1
calving	May	1
movement	Jun	1
movement	Jul	1
recruitment	Jul	1
movement	Aug	1
movement	Sep	1
movement	Oct	1
movement	Nov	1
movement	Dec	1
...	...	...
movement	Jan	30
logging	Jan	30

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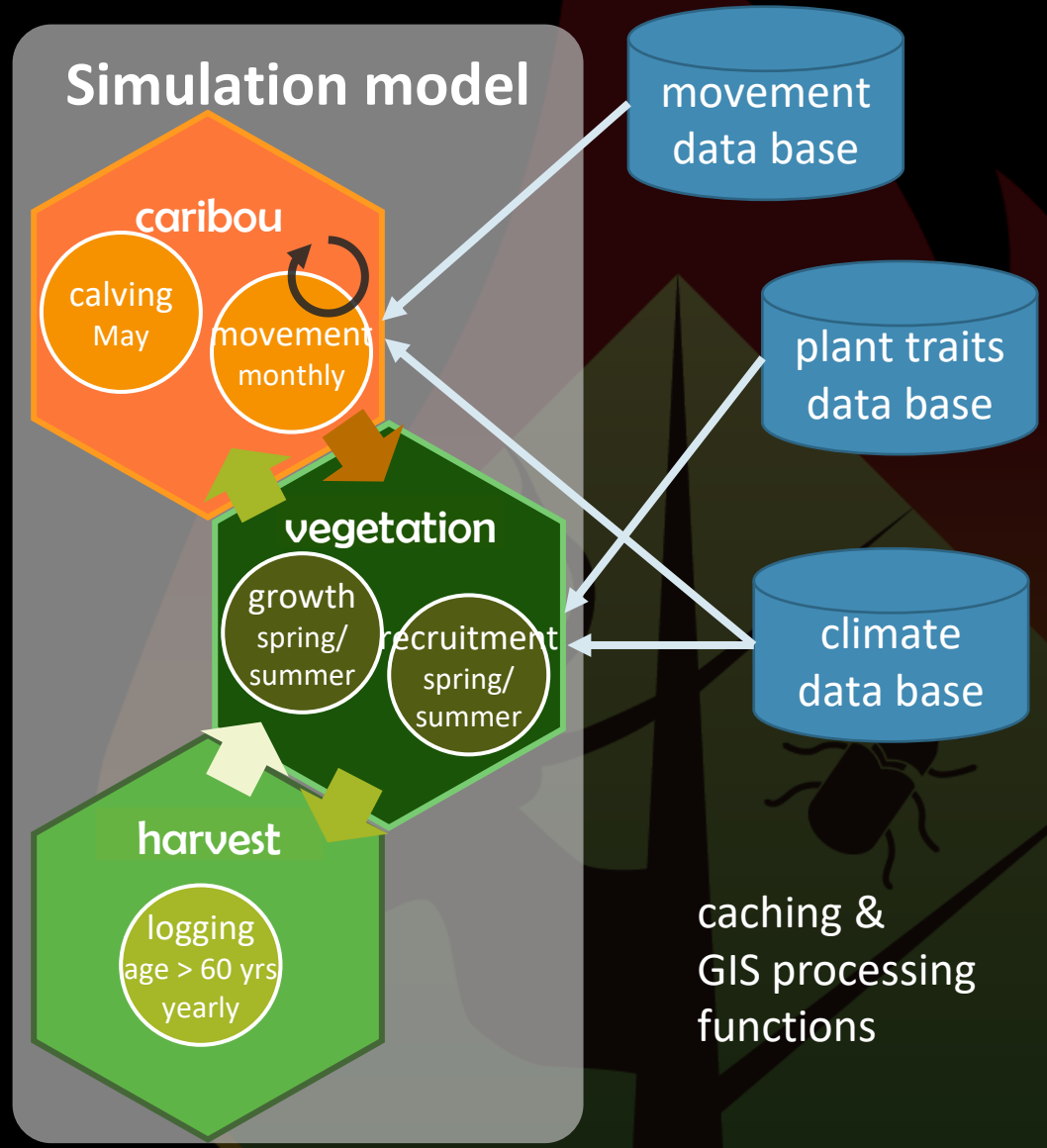
- ✓ Modules connected directly to (raw) data



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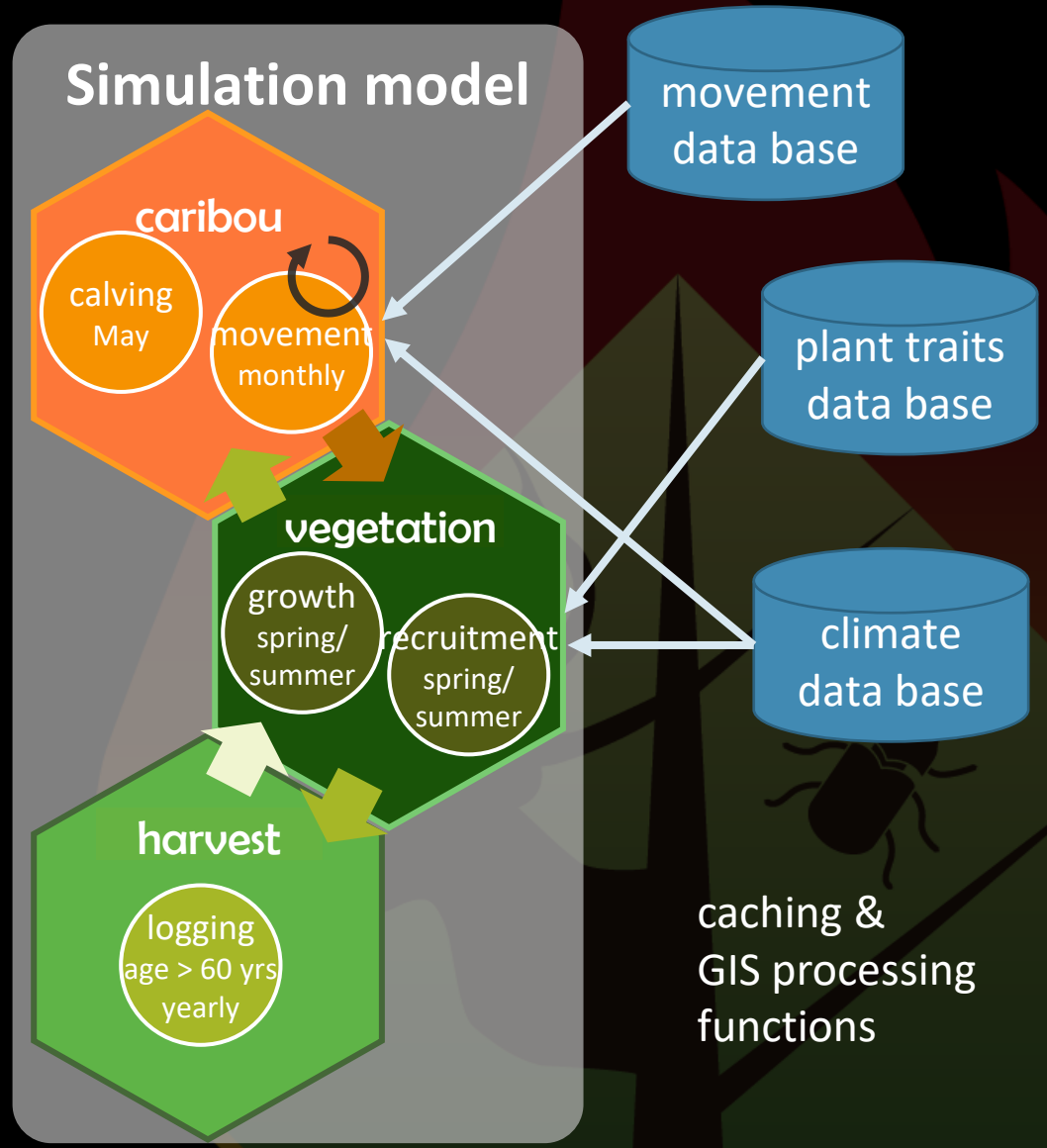
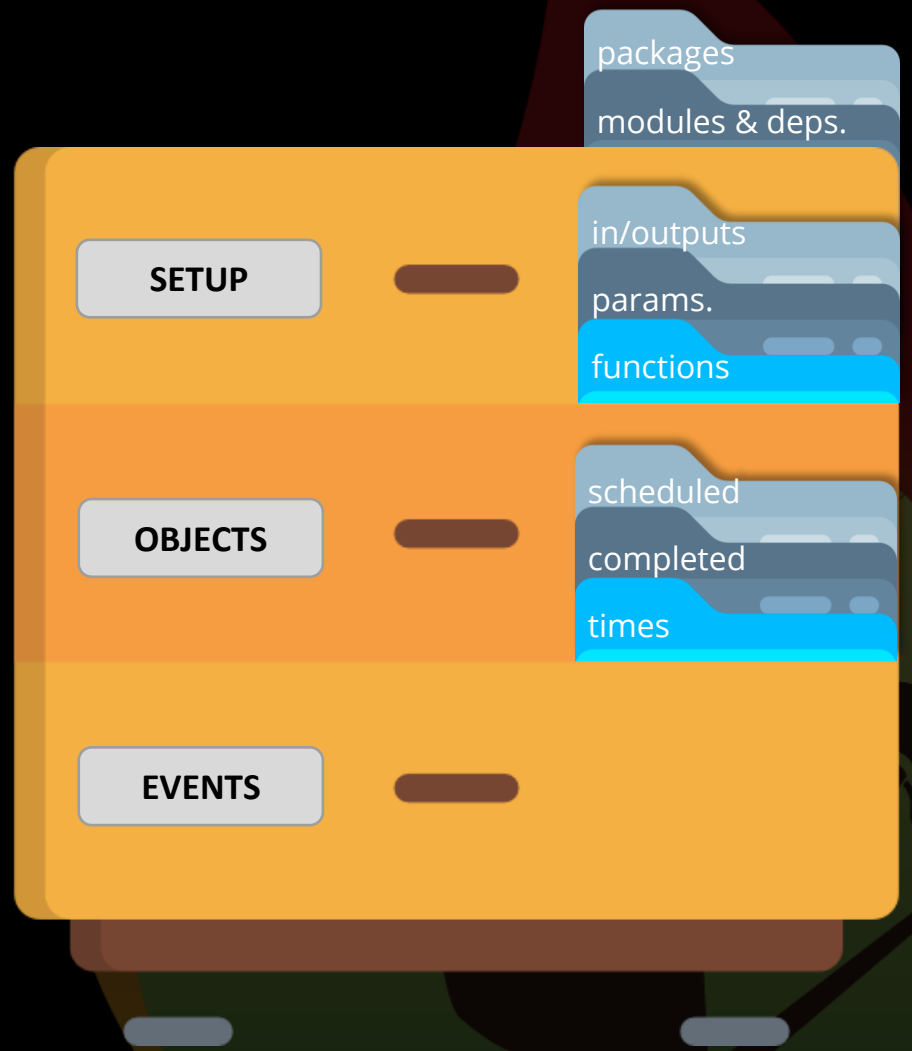
- ✓ Modules connected directly to (raw) data
- ✓ Time-consuming (and non-stochastic) operations can be cached



SPADES BASICS

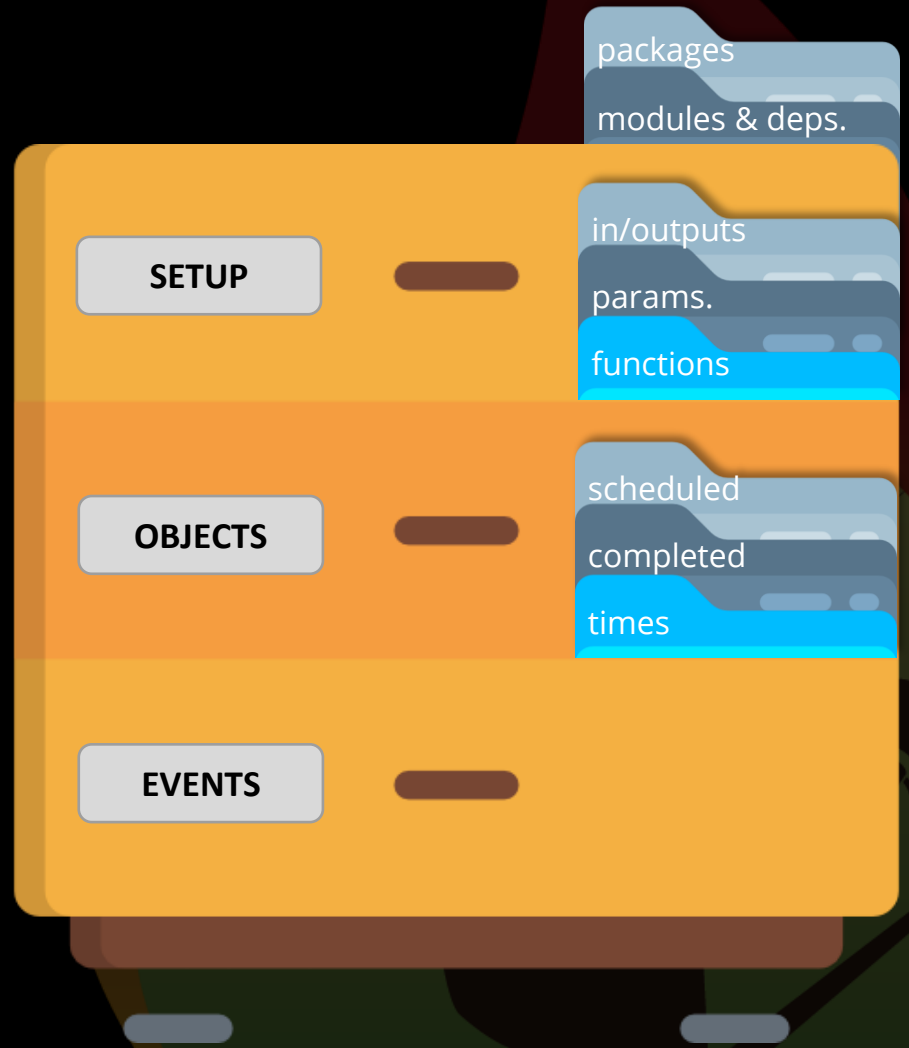
- ✓ Everything is contained and accessible via a `simList`



SPADES BASICS

- ✓ Everything is contained and accessible via a `simList`
  - ✓ Facilitates inspecting parameters and inputs *a posteriori*
  - ✓ Facilitates tracking uncertainty
  - ✓ + caching = faster development

The `simList`



TIME TO LOOK AT SOME CODE

Robust and nimble scientific workflows, using SpaDES

Workshop Agenda

This is a *hands-on* workshop

Please **ask questions**, share your troubles and successes

Last 15 min of each WOYO is for discussion

We are always available via **Teams chat**